Dijet Azimuthal Decorrelations
vs
NLO pQCD, Herwig and Pythia

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Special thanks to:
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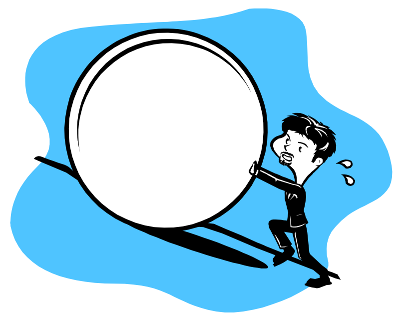
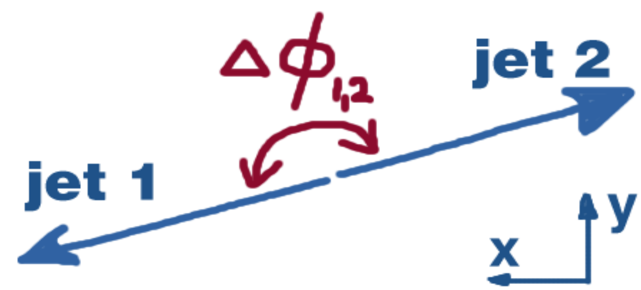
All results presented here are PRELIMINARY!



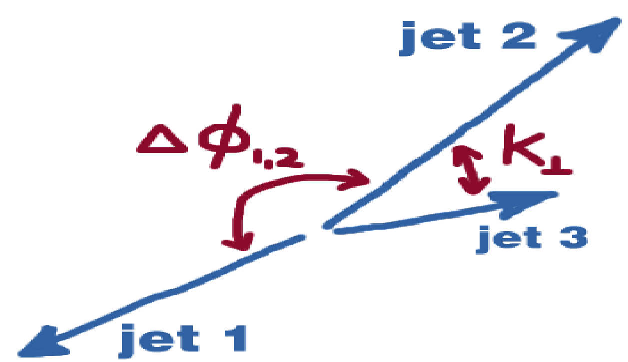
Theoretical Motivation

- In $2 \rightarrow 2$ scattering, partons emerge back-to-back ➜ additional radiation introduces decorrelation in $\Delta\Phi$ between the two leading partons/jets
  - ➔ Soft radiation: $\Delta\Phi \sim \pi$
  - ➔ Hard radiation: $\Delta\Phi < \pi$
- $\Delta\Phi$ distribution is directly sensitive to higher-order QCD radiation
- Testing fixed-order pQCD and parton-shower models across $\Delta\Phi$:
  - ➔ $\Delta\Phi \sim \pi$:
    - ❖ FO calculations unstable
    - ❖ PS Monte Carlo's applicable
  - ➔ $2\pi/3 < \Delta\Phi < \pi$:
    - ❖ First non-trivial description by $2 \rightarrow 3$ tree-level ME
    - ❖ $2 \rightarrow 3$ NLO ME calculations became available recently (NLOJET++)
  - ➔ $\Delta\Phi < 2\pi/3$ (3-jet "Mercedes")
    - ❖ $2 \rightarrow 4$ processes and higher

Dijet production in lowest-order pQCD



3-jet production in lowest-order pQCD



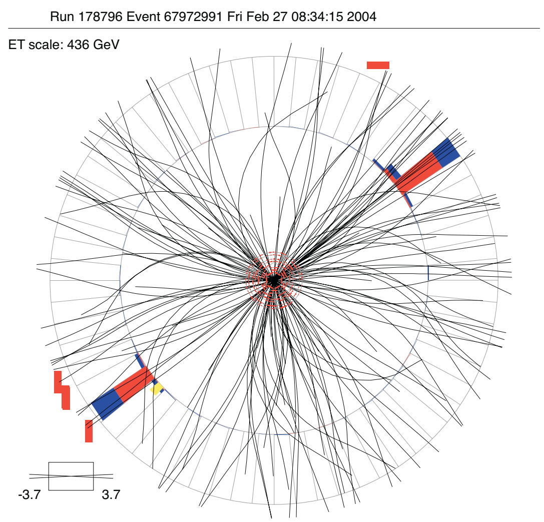
Experimental Motivation

- Observable: ΔΦ distribution between the two leading jets normalized by the integrated dijet cross section

$$\frac{1}{\sigma_{\text{dijet}}} \cdot \frac{d\sigma_{\text{dijet}}}{d\Delta\Phi}$$

- Advantages:
  - ➔ ΔΦ is a simple variable, uses only the two leading jets
  - ➔ No need to reconstruct any other jets!
  - ➔ Jet direction is well measured
  - ➔ Reduced sensitivity to jet energy scale

M_{jj} = 1206 GeV

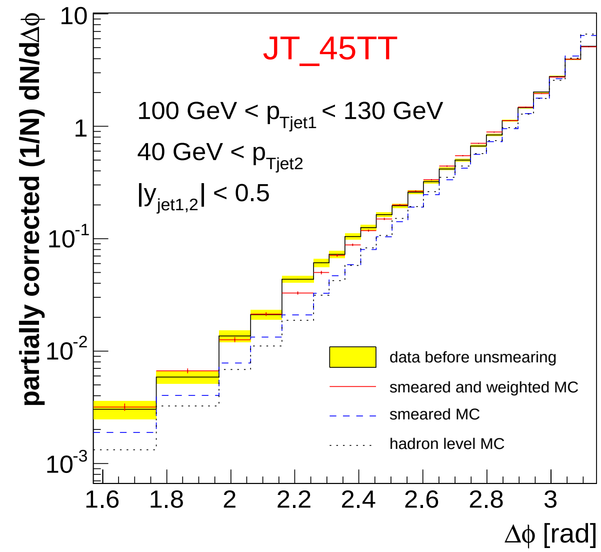


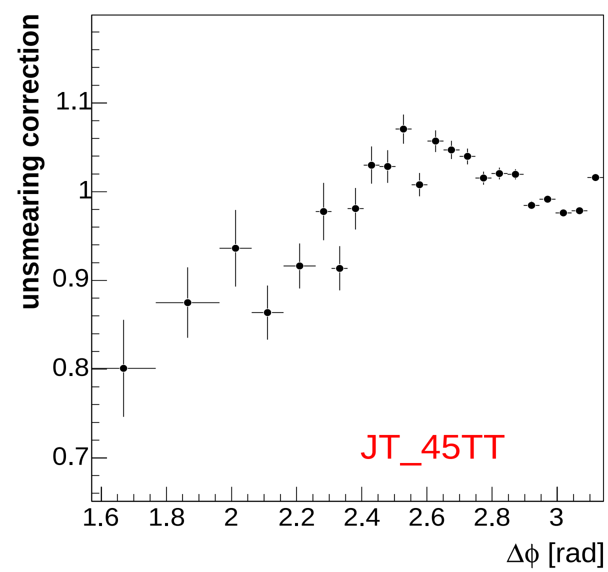
Analysis Overview

- Data sample:
  - ➔ ~150 pb^{-1} used in analysis
  - ➔ At least two jets reconstructed with cone R=0.7
  - ➔ Require that two leading jets are central: $|y_{jet1,2}|<0.5$
  - ➔ Jet p_T's in the region of full trigger efficiency
  - ➔ Running conditions, jets, vertex, missing E_T satisfy quality requirements
- Corrections for:
  - ➔ Cut efficiencies
  - ➔ Jet energy scale
  - ➔ Resolution smearing (unfolding)
- $\Delta\Phi$ distribution measured only for $\Delta\Phi>\pi/2$ to avoid jet overlaps

Resolution Unfolding

- Unfolding procedure:
  - ➔ Start with the $\Delta\Phi$ spectrum obtained for jets reconstructed at hadron level in events from Pythia
  - ➔ Smear this spectrum according to measured resolutions in $\Delta\Phi$ (from MC) and p_T (from data)
  - ➔ Reweight the resulting spectrum to fit the data
- Correction = unsmeared spectrum/ smeared spectrum (bin-by-bin, after reweighting)
  - ➔ Includes effects of jet reordering due to smearing in p_T
  - ➔ Shapes similar in all p_T ranges
  - ➔ Unfolding corrections not huge
  - ➔ Work in progress

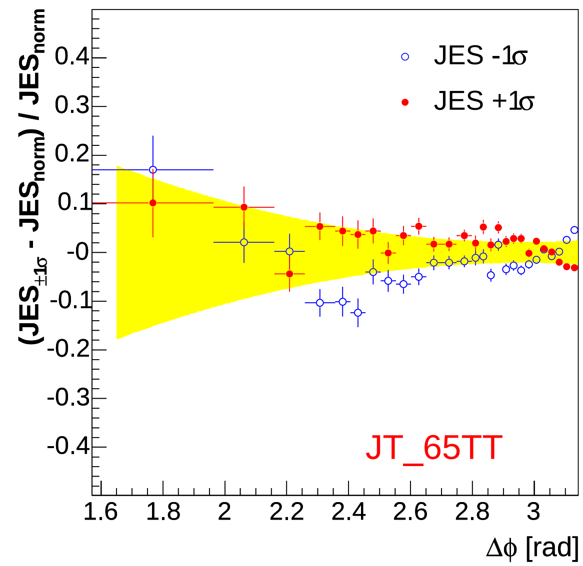


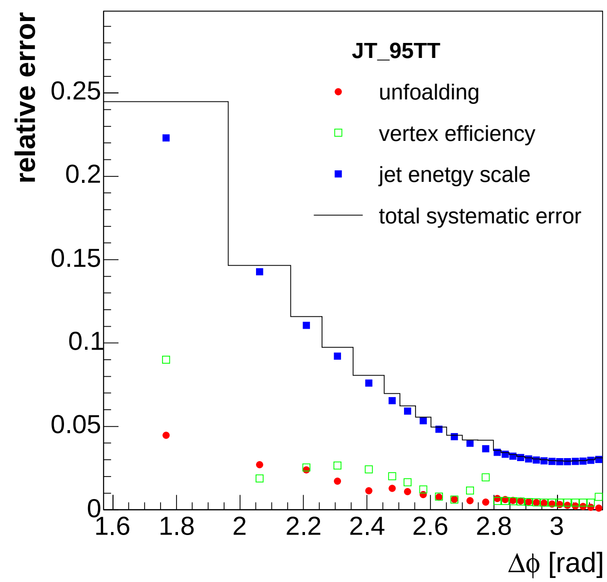


Systematics

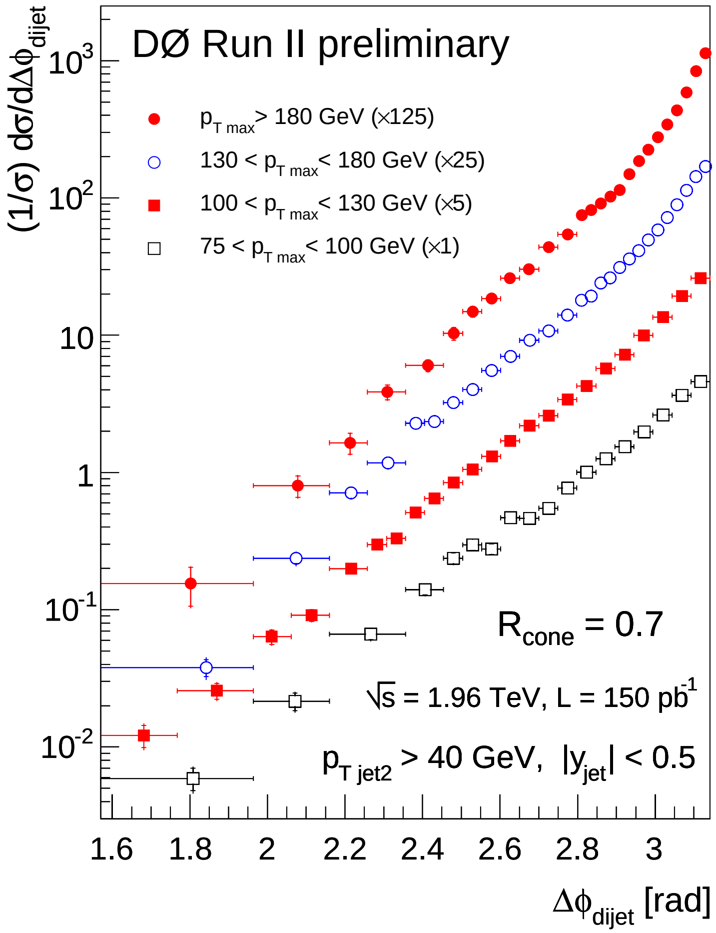
- Jet energy scale still results in a substantial uncertainty
  - ➔ But, fractionally, much smaller than in the case of the absolute cross sections
  - ➔ A new jet energy scale determination, with significantly smaller uncertainties, is propagating through the analyses
- Other sources:
  - ➔ Vertex efficiency
  - ➔ Unfolding (under study)
- Estimated uncertainties:

  ~5% ($\Delta\Phi\sim\pi$) to ~25% ($\Delta\Phi\sim\pi/2$)



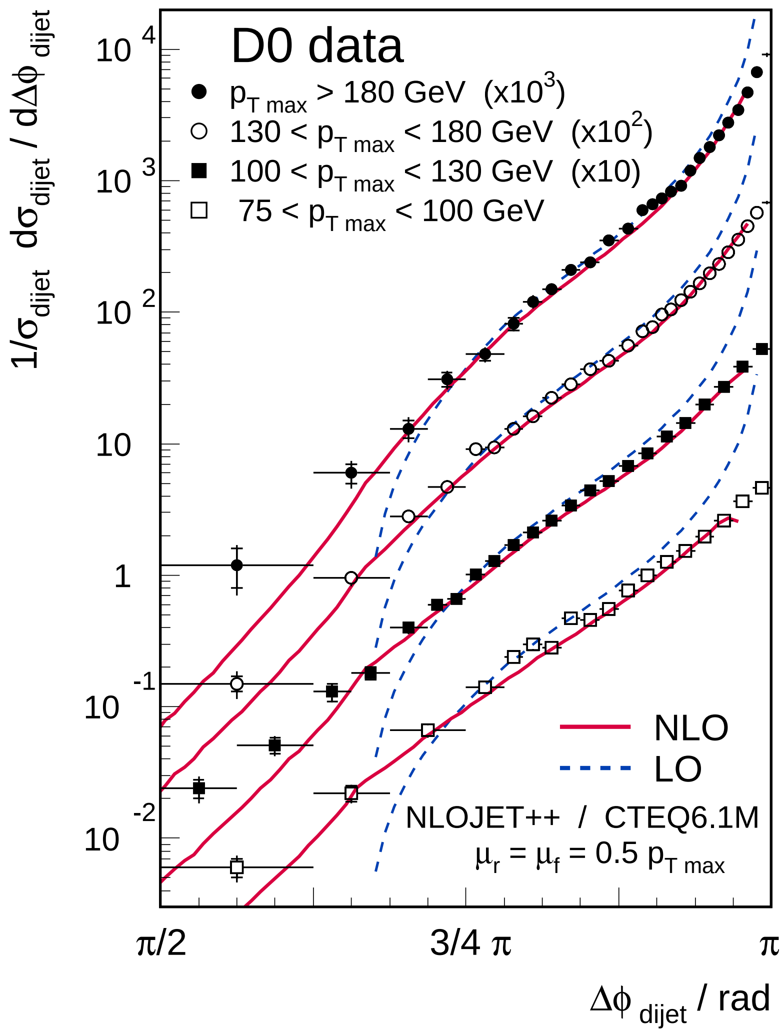


Results: Dijet Azimuthal Decorrelations



- Recap:
  - ➔ Central jets |y| < 0.5
  - ➔ Second-leading p_T > 40 GeV
  - ➔ Leading jet p_T bin thresholds:
    - ❖ 75, 100, 130, 180 GeV
- Towards larger p_T, $\Delta\Phi$ spectra more strongly peaked at ~π
  - ➔ Increased correlation in $\Delta\Phi$
- Distributions extend into the "4 final-state parton regime", $\Delta\Phi<2\pi/3$

Comparison to Fixed-Order pQCD

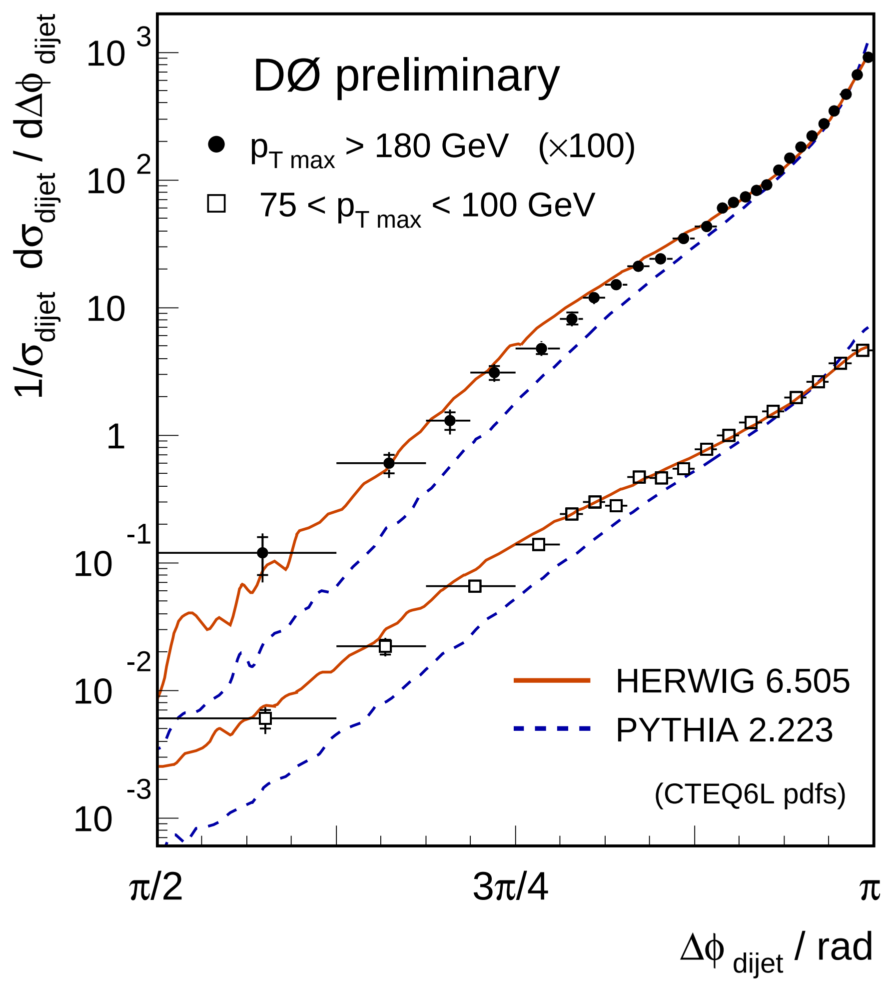


- Leading order (dashed blue curve) – clear limitations
  - ➔ Divergence at $\Delta\Phi = \pi$ (need soft processes)
  - ➔ No phase-space at $\Delta\Phi<2\pi/3$ (only three partons)

- Next-to-leading order (red curve)
  - ➔ Good description over the whole range, except in extreme $\Delta\Phi$ regions

Comparison to Parton-Shower Monte Carlo's

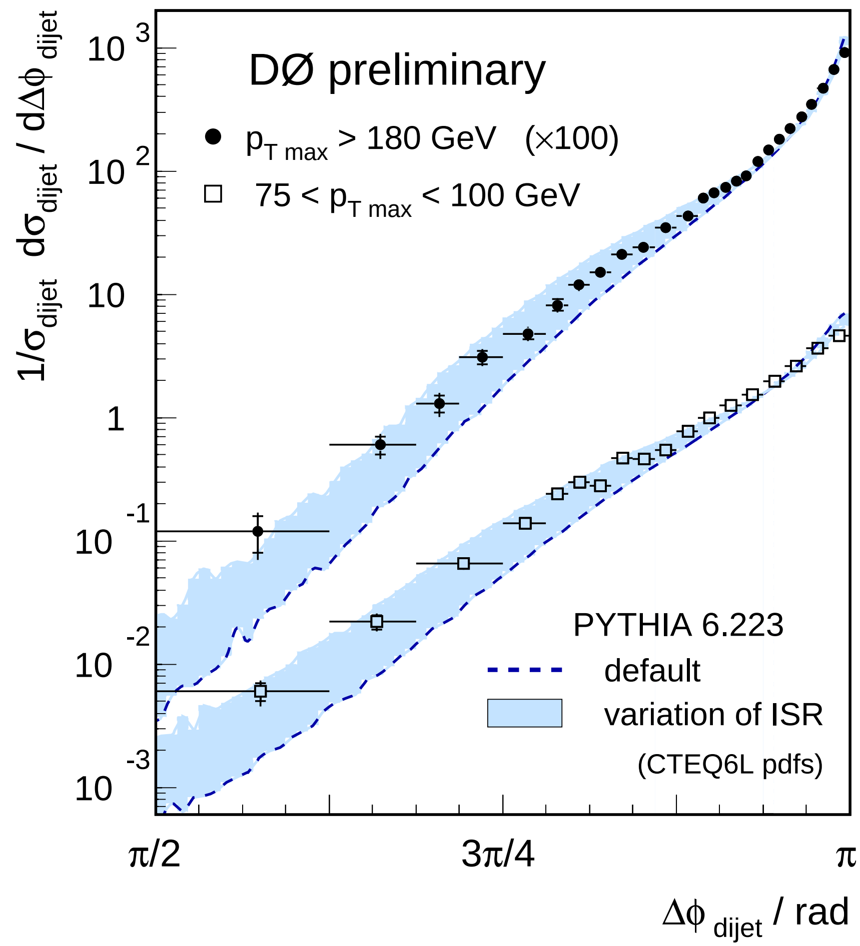
- Testing the radiation process:
  - ➔ 3rd and 4th jets generated by parton showers
    - ❖ Soft and collinear approx.
- HERWIG 6.505 (default)
  - ➔ Good overall description!
  - ➔ Slightly too high in mid-range
- PYTHIA 6.223 (default)
  - ➔ Very different shape
  - ➔ Too steep dependence
  - ➔ Underestimates low ΔΦ



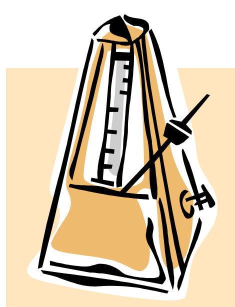
CTEQ6L

Impact of ISR in Pythia

- ΔΦ distributions are sensitive to the amount of initial-state radiation
  - ➔ Plot shows variation of PARP(67) from 1.0 (current default) to 4.0 (previous default, Tune A)
    - ❖ PARP(67) controls the scale of parton showers
  - ➔ Intermediate value suggested

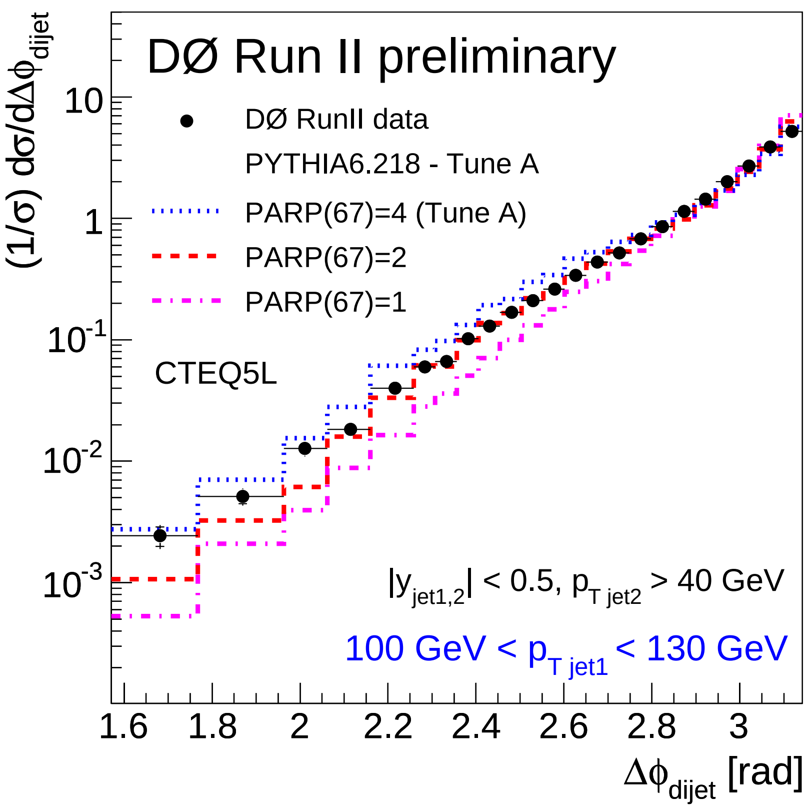


- More PYTHIA tuning possible!

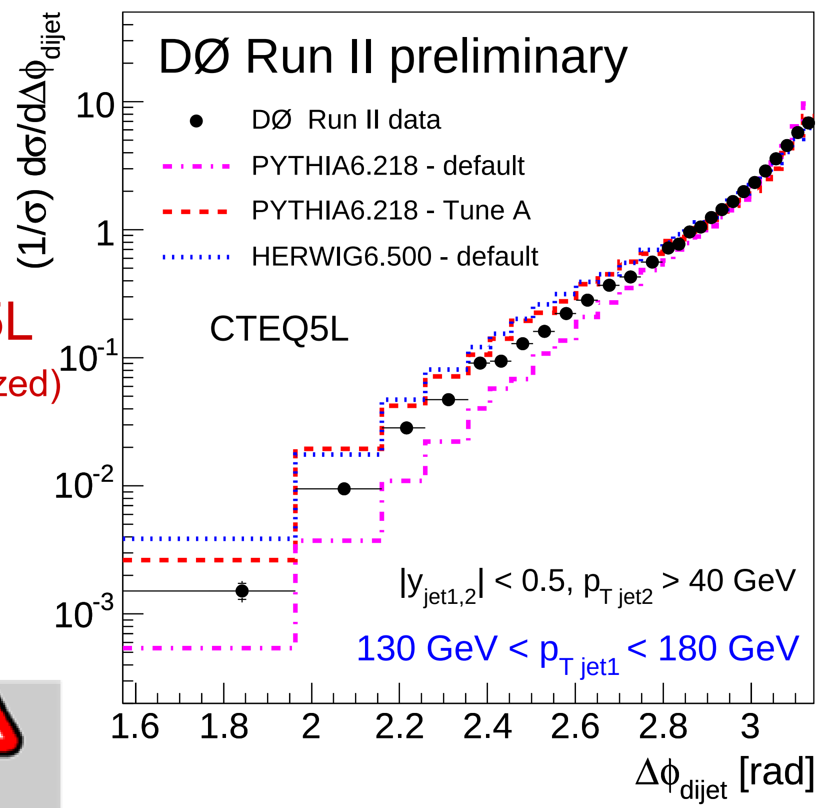


ΔΦ, Tune A, CTEQ5L and All That…

- Most of variation from PARP(67)
  - ➔ Sensitivity to soft underlying event small
- HERWIG prediction with CTEQ5L (parameterized) not as good as with CTEQ6L



CTEQ5L
(parameterized)



Summary and Outlook

- The ΔΦ distribution has been measured for central jets in four p_T regions using 150 pb^{-1} of DØ Run II data
  - ➔ Sensitive to higher-order QCD processes
  - ➔ Test of 3-jet NLO pQCD at Tevatron
    - ❖ good agreement for most of ΔΦ range
  - ➔ Prospects for tuning parton-shower Monte Carlo's
    - ❖ Herwig doing well, sensitivity to ISR in Pythia
- Plans, hopes, dreams:
  - ➔ Extend the measurement to lower p_T values
    - ❖ More sensitivity to initial-state gluons
    - ❖ A handle on quark vs gluon induced showers
  - ➔ Extend to forward rapidities for one of the jets
    - ❖ Probe even smaller values of ΔΦ
    - ❖ More sensitivity to initial-state gluons
  - ➔ Extend to b-tagged jets
    - ❖ Probe gluon→bbar splitting
    - ❖ Interesting overlap with top, Higgs physics…

Frixione, Nason, Webber